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THE VOLCANIC HISTORY OF LASSEN PEAK

Lassen Volcanic National Park, California

View of Lassen Peak looking southeast from near Manzanita Lake. A small jet of steam from the crater is being blown to the south

By

J. S. DILLER
Geologist, United States Geological Survey

With an Introductory Note on the National Park

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INTRODUCTORY NOTE.

While volcanoes occur in many parts of the United States, the volcanic field which has affected our scenery in the most distinguished manner lies in our Northwest. It includes no less than three national parks in the Cascade Mountains, Mount Rainier, Crater Lake, and Lassen Volcanic, and, farther east in Wyoming, the celebrated Yellowstone. Lassen Peak lies in northern California, at the southern end of the Cascade Mountains. Its period of relatively small eruptions since the spring of 1914, following upon a quiescent period of about 200 years, centered the national gaze upon it and Congress created it a national park on August 9, 1916. It is the only volcano in the United States now regarded as active, although Mount St. Helens and Mount Baker have been active within recorded history.

Since the close of its period of most vigorous activity in 1915, Lassen Peak has remained comparatively quiet. Many hot springs and other minor phenomena attest its condition of internal heat, and from time to time, at decreasing intervals, the volcano emits quantities of steam and smoke. There may be later explosions, but Lassen's history as a dying volcano offers a reason for not expecting great outbreaks. It may be classed to-day between semiactive and active.

Lassen Volcanic National Park offers to the visitor an exhibit of volcanic forces in semiaction which is interesting and instructive. The Peak rises 10,460 feet in altitude. Cinder Cone rises 6,907 feet. There are smaller volcanic peaks and lava fields, fumaroles, hot springs, and mud volcanoes or solfataras, as well as boiling lakes and other interesting phenomena of a volcanic region. There are also many cold lakes and trout streams in majestic forested tablelands and canyons. The national park contains 124 square miles.

THE VOLCANIC HISTORY OF LASSEN PEAK.[1]

By J. S. Diller.

Lassen Peak is in northeast California and forms the southern end of the Cascade Range. It stands between the northern end of the Sierra Nevada and the Klamath Mountains, a mighty volcano that rises to an elevation of more than a mile above the early Tertiary and Cretaceous sedimentary rocks on which it rests. It is on the edge of one of the greatest lava fields in the world, extending from northern California, Oregon, and Washington eastward across Idaho into the Yellowstone National Park of Wyoming, and covering an area of about 250,000 square miles. Over the eastern portion of this field most of the lava is basalt, which was very liquid at the time of its eruption and, spreading far and wide like water, it formed a flattish country, the great plains of Snake River and the Columbia, but along the western border the lava is chiefly andesite, a viscous lava that piled up about the vents from which it issued and built up a range, the Cascade Range, surmounted by great peaks, from Lassen Peak, which rises 10,460 feet, to Shasta and Rainier, that attain an elevation of more than 14,000 feet.

In the volcanic belt of the Alaskan coast there are a number of vigorously active volcanoes. So also in Central America and Mexico, but in the Cascade Range the volcanoes appear to be near extinction.

Since the white man settled on our Pacific coast there has been but little volcanic activity. In 1843, about the time Fremont, the pathfinder, made his memorable trip across the continent, Mount Baker and Mount St. Helens in the State of Washington were both in eruption, spreading a blanket of volcanic dust over the country as far south as the Columbia, where at The Dalles a missionary gave a sample to Fremont.

Prof. Davidson, of the United States Coast Survey, in 1854 saw an eruption of Mount Baker. The summit was obscured by vast rolling masses of dense smoke, which in a few moments reached an estimated height of 2,000 feet above the summit and soon enveloped it entirely. In 1858 Mr. J. S. Hittell saw the clouds over Mount Baker brilliantly illuminated by an eruption then taking place.[2]

[1] Published by permission of Director of U. S. Geological Survey. Reprinted from Science, May 26, 1916.

[2] "The United States," J. D. Whitney, p. 115.

Mount Rainier and Mount Shasta emit heated vapors from the fumaroles on their summits, giving evidence that their interiors are still hot.

The present activity of Lassen Peak, though feeble as compared with its earlier eruptions, is proof that it must still be classed as an active volcano.

The volcanic activity which resulted in the upbuilding of Lassen Peak began near the close of the Eocene. The lava flows appear to have been largest and most numerous in the Miocene and Pliocene, successive flows decreasing in size during the Quaternary to near extinction in recent times.

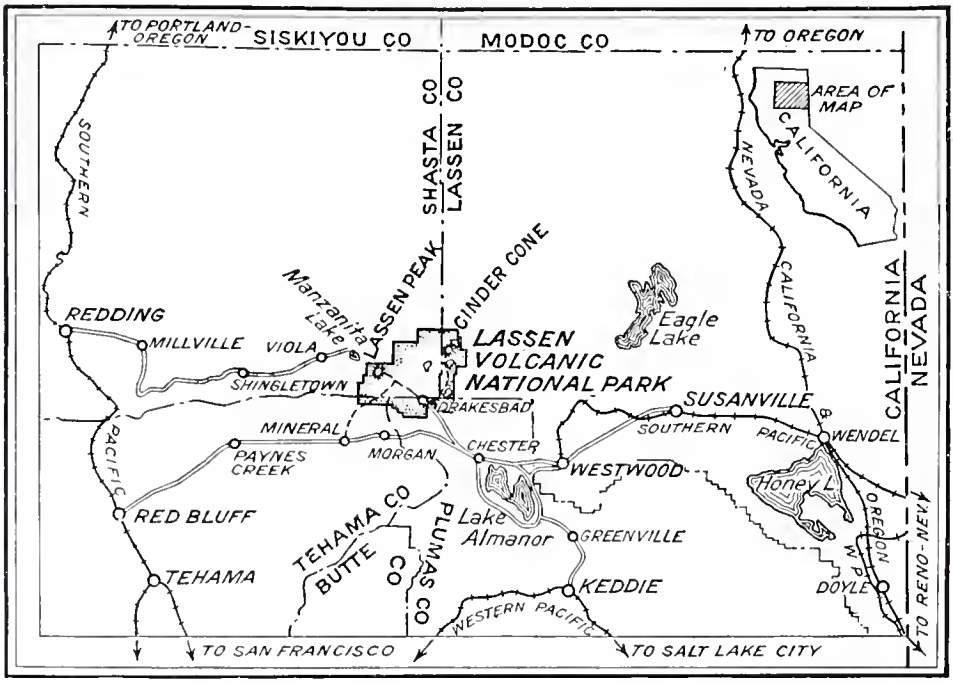

FIG. 1.—Lines of approach to the Lassen Volcanic National Park railroads, wagon roads, and trails to Lassen Peak and Cinder Cone, which are 10 miles apart and within the boundary of the park.

There were long periods of interrupted activity separated by long intervals of quiescence. During the active periods both explosive and effusive eruptions were common; the one forming cinder cones and sheets of volcanic agglomerate and tuff; the other forming lava fields whose ruggedness was proportional to the viscosity of the erupting lava.

Lassen Peak is a volcano of large type surrounded by many smaller ones of later date, the whole being built up of a notable variety of lavas. The oldest lavas of the Lassen Peak region are of intermediate chemical composition belonging to andesites. The early magma yielding the erupting andesitic lavas in the course of time differentiated into two portions. On the one hand it became more sili-

ceous (salic), erupting as dacite and rhyolite, and on the other hand it became less siliceous (mafic), yielding basalt and quartz basalt. All varieties are well represented in the Lassen Peak region and are derived apparently from the same magma.

As the volcanic center developed the most active crater migrated. The first crater was in the head of Mill Creek. It was not only the oldest, but also the largest crater, more than a mile in diameter. Composed of andesitic lavas, it rose to a height of 9,400 feet. The peak named "Brokeoff Mountain" on the Forest Service maps is the most prominent remnant of this great crater in the head of Mill Creek.

The second great crater opened on the northern edge of the first and erupted dacite, building up Lassen Peak to its present height with a summit crater about a quarter of a mile in diameter.

The third crater, about 4 miles a little west of north from the first, opened only a few centuries ago at the northwest base of Lassen Peak, and the rugged lava flows from it formed Chaos Crags.

The products of this eruption in Chaos Crags are well preserved and their relations clearly visible. The eruption began by a succession of explosions that spread a thin layer of volcanic sand and dust over the surrounding country and ended in the extravasation of a most rugged mass of dacite which, though at first glance having the aspect of granite, is rich in volcanic glass, generally of dark color, somewhat pumiceous and full of inclusions like the dacites of Lassen Peak.

The fourth crater of Lassen Peak is the new crater, active at the present time. It began by a slight explosion within the old crater, second of those enumerated, on the summit of Lassen Peak, and is remarkable for its place of outbreak, as well as its low energy, the small mass of material erupted and the continuity of the activity. Like the eruption of a few centuries ago at Chaos Crags, it had two phases, one explosive, the other effusive.

During the first phase the explosive eruptions were of gas carrying out with it rock fragments and dust only. The size of the crater increased with each eruption, as shown in figures 2 and 4. The second phase, which is effusive, includes also an eruption of lava, which formed a lid on the volcano and overflowed to the west, as represented in figure 3.

In the beginning the new crater was confined to the loose material filling the old crater, but later it reached the solid rock of the old crater rim and finally after more than 150 eruptions it attained near the end of March, 1915, a size of about 700 to 1,000 feet.

Ejecta accumulated on the rim of the new crater to a depth of 30 to 40 feet. The largest stone ejected was 15 feet in diameter and weighed about 63 tons. Small stones were thrown as much as a mile

from the crater, but beyond 2 miles from the crater scarcely more than a trace of dust could be noticed except to the northeast, the direction of the strongest winds and that taken by the great blast of the eruption May 22, 1915.

By far the greatest eruptions that have occurred at Lassen Peak since its present activity began are those of the night of May 19 and

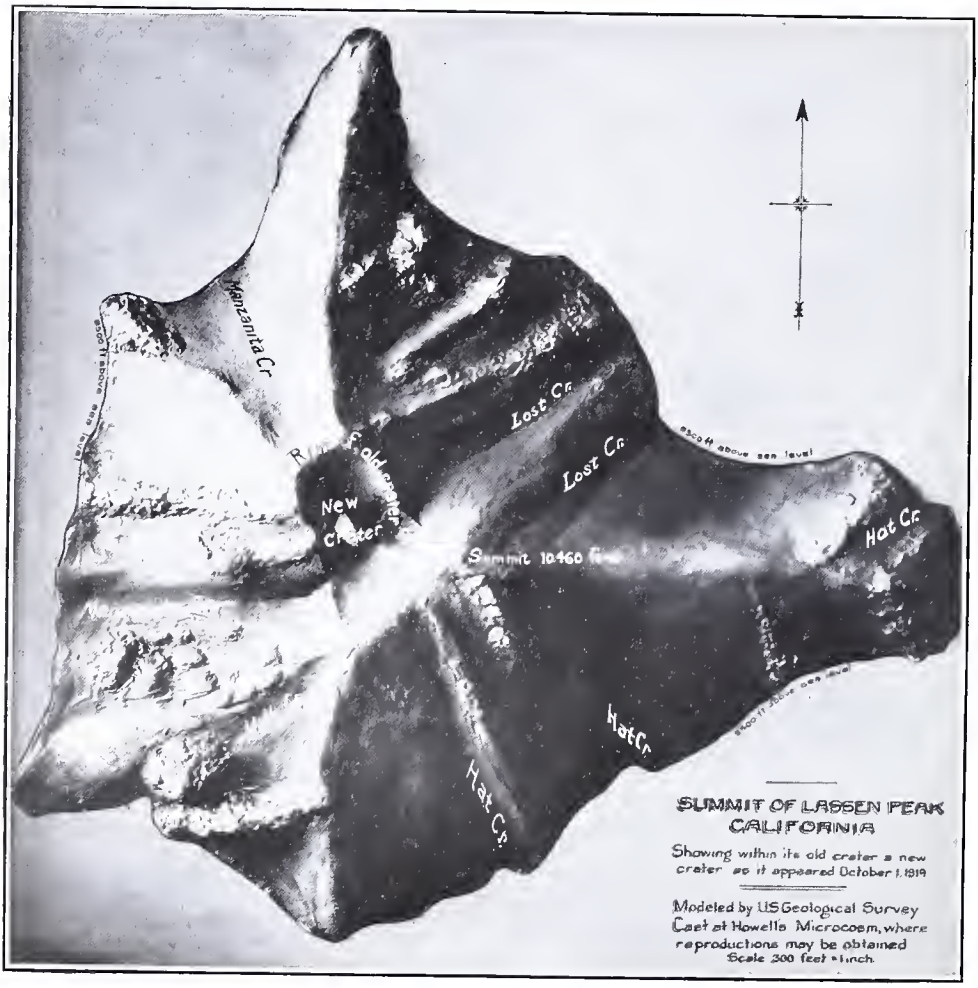

FIG. 2.—Summit of Lassen Peak, Cal., above the 9,500-foot contour, as seen from above, showing the summit spurs radiating from the rim of the old crater, within which the small new crater (white), as it appeared October 1, 1914, contains a jet of steam.

The new crater elongated and widened (Fig. 4) by successive eruptions until about the end of March, 1915, when it occupied by far the greater portion of the old crater, and then the bottom began to upheave.

Modeled by the U. S. Geol. Survey. Cast at Howell's Microcosm, Washington, D. C., where reproductions may be obtained.

the afternoon of May 22, 1915. The first great result was the extrusion of new lava and the formation of a lava lid which culminated in the second great feature, the devastation of the Lost Creek and Hat Creek country by horizontal blasts of hot gas.

About the end of March, 1915, the old crater having been thoroughly cleaned out by explosive eruptions and the superincum-

bent load largely removed from the magma, it began to rise in the volcanic conduit and initiated the second stage, the effusive stage, of the volcanic activity. The hot magma apparently more or less viscous in the volcanic conduit, was forced upward by pressure of magma or gas from beneath and was gradually upheaved, with great escape of steam, until it reached the surface as new lava, and as a

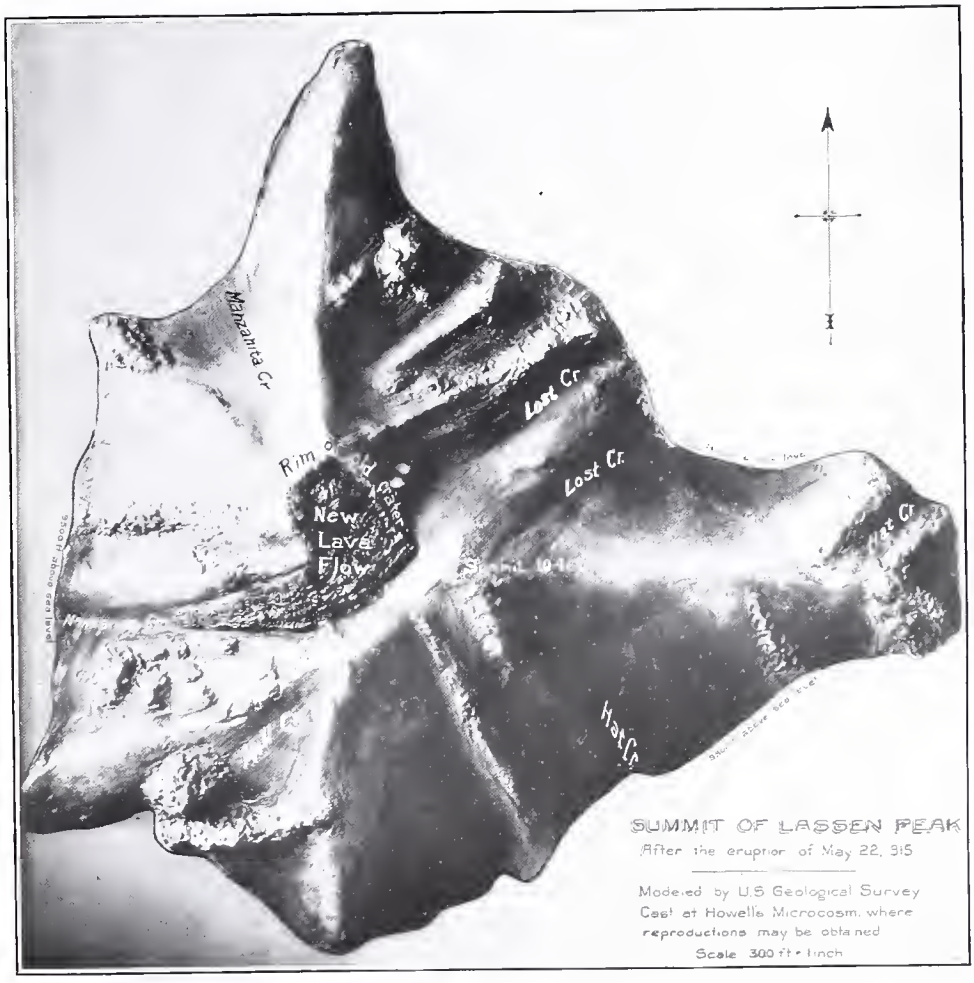

FIG. 3.—The upheaval of the bottom within the new crater began probably about April 1, 1915, and, continuing through April and early May, culminated in the great eruption of May 22, 1915, which resulted in the extrusion of a mass of new lava, so that it filled both the new and old craters to the rim as a "lid," and, overflowing through the notch, the new lava extended a short distance down the west slope. The hot blast that devastated the Hat Creek country escaped from beneath the edge of the lava lid at the head of Lost Creek.

Jets of steam are shown on the northeast slope. The jets of steam from the northwest fissure and on the west slope are not clearly visible in the high light.

lava table filled not only the new, but also the old crater so as to form a lid on the volcano. The lava overflowing from the edge of the lid through a notch in the old rim, as shown in figure 3, passed down the west slope of Lassen Peak about 1,000 feet.

On the night of May 19 and especially also on the afternoon of May 22, 1915, the eruptions were violent. A mushroom-shaped cloud

was hurled to the height of about 4 miles above the summit of the mountain and afforded a magnificent spectacle as seen from the Sacramento Valley. At night [1] flashes of light from the mountain summit, flying rocketlike bodies and cloud glows over the crater reflecting the light from incandescent lavas below were seen by many observers from various points of view and appear to indicate that much of the material erupted was sufficiently hot to be luminous.

Prof. R. S. Holway, who was one of the first observers to ascend the mountain after the eruption, saw it on May 27, five days after

FIG. 4.—Looking northwest from the rim of the old crater across the new crater, August 17, 1914, after it had been enlarged by 25 eruptions. The sand and bowlders ejected from the new crater cover all the slopes of the old crater in view and the deposits are stratified as seen on the inner slope of the new crater.
Photo © by P. J. Thompson.

the eruption, and states that "hissing steam was escaping from many cracks and crevices and the shimmering air above all telling of the hot rocks below."

J. M. Howell's party visited the summit May 30, eight days after the eruption, and Mr. Spaulding reports that "the heat from the upheaved mass was intense. The air above it shimmered with heat waves like the desert on a boiling summer day."

That the new lava in the lid at the time of its eruption was so hot at least in spots as to be luminous appears evident and it is probable

[1] Luminous phenomena were reported on the nights of September 29, 1914, May 14, 15, 17, and 19, 1915, as well as June 20 and October 20 of the same year. Some of the phenomena reported may be explained as due to the reflected rays of the setting sun, but this can not be true of all.

that the temperature to produce luminosity, say 600° to 1,000° C. would at the same time give to the slowly rising lava such a degree of viscosity as to enable it to adjust itself to its surroundings and overflow the crater rim.

Although the lava lid in places appears to be a mass of tumbled rock fragments, yet there are large portions of it essentially continuous, as if forced up in viscous condition and broken later as a result of the cooling, flowing and subsidence of the mass within the crater. The postmaster at Manton reports that a change was noticed on the summit of the mountain for a few days previous to May 19. A black wedge-shaped mass of lava appeared in the middle of the new crater, getting higher every day, and finally in plain view spilling over through the notch on the west slope.

Many volcanic bombs were ejected by explosive eruptions during the effusion of the new lava. They range up to 5 feet or more in diameter and are most abundant at the foot of the steeper portion of the northwest slope. Many of them have a peculiar compact crust with a cracked surface like bread crust, suggesting the name "bread-crust bombs," and they are regarded as the luminous ejecta seen in connection with several eruptions by observers from different points of view. Very few other portions of the erupted magma afford such impressive evidence of fusion as the bread-crusted bombs.

Although the extrusion of the new lava and the formation of the lava lid was the main feature of the great eruptions in May, it was far surpassed in interest and wonder by the remarkable horizontal eruptions of the hot blasts that devasted Lost and Hat Creeks.

On the night of May 19 it appears that the body of superheated gases which accumulated beneath the lid, forcing it up, escaped from under the edge with terrific force down the deep snow-covered northeast slope of Lassen Peak toward Lost Creek and Hat Creek. The snow was instantly converted into water, and the mighty onrush of water and blast of hot gases swept everything before it for more than 10 miles along Lost Creek, forming a devastated belt from a few hundred yards to a mile in width. Meadows were buried beneath finer débris and occasional large bowlders broken off from the edge of the lava lid far above. Trees 3 feet in diameter were broken off or uprooted and the country scoured as by a mighty sand-blast (Figs. 5 and 6). The fine green leaves of the pine trees left standing along the borders of the blast were killed by the heat and turned brown. Locally, on favorable slopes, the heat was so great that the green leaves were charred; not only those of the pine but also those of the Manzanita, several acres of which, at a distance, had the general appearance of an area swept by a forest fire. In fact, it is stated by Mr. Fred Seaborn, of the Forest Service, who was in that region a few days later, that two fires were actually kindled by the eruption.

This reminds one of the hot blast from Mount Pelee that destroyed St. Pierre. Luckily in the Hat Creek region there were only a few summer residents. Warned by the noise of the approaching torrent, they escaped to the hills.

That no one was killed was simply a matter of good fortune on the part of the 11 enthusiasts who early visited the region to make a photographic record. Mr. B. F. Loomis, the veteran photographer of Viola, was among them.

There were two hot blast eruptions into the Hat Creek country; one on the night of May 19 and the other on the afternoon of May 22.

FIG. 5.—The divide between Lost Creek and Hat Creek after the hot blasts uprooted the trees and scoured them with flying sand. On the border of the devastated area the green leaves of the pines were seared and locally scorched by the hot gasses to a distance of more than 2 miles from the crater.

The Loomis party arrived on the scene about noon, May 22, and spent several hours photographing up to the head of Lost Creek, making a record of what was accomplished by the first blast. They left soon after 3 o'clock and had scarcely reached the west side of Chaos Crags when the most violent eruption occurred, sending its column of smoke to a height of more than 20,000 feet, as seen from the Sacramento Valley, and a hot blast down the slope into the Hat Creek country that would probably have killed the whole party had the eruption occurred a few hours earlier.

At the time of the great outbreak a fissure was opened running from the summit northwest about 1,000 feet down the slope toward Chaos Crags. Three vents were opened on this fissure, and the

greater portion of the volcanic activity during the summer of 1915 was confined to this fissure. G. W. Olsen, who ascended Lassen Peak October 19, 1915, reported the northwest fissure quiet, but another one active a few hundred feet east of it on the northern rim of the lid.

Fumaroles have developed at a number of points on the north and west slopes of Lassen Peak within 800 feet of the summit, but all the violent eruptions have occurred at or very near the summit. No fumaroles have appeared on the south and east slopes, the direction of easiest approach, where at lower levels, 5,800 to 7,400 feet, fumaroles and solfataras are such active features at Bumpass Hell, the Devils Kitchen, and Tartarus or Boiling Lake. These solfataras

FIG. 6.—From the lower end of Jessen's Meadow, showing the once rich pastures converted into a waste of sand, gravel, and bowlders. In the foreground are the logs of pines which once stood on the divide between Lost and Hat Creeks.

within 3 miles of Lassen Peak have been active with but little change during the last 50 years. They are on the strongest side of Lassen Peak and have not been affected by the eruptions at its summit, 4,000 feet above them.

The total mass of material transferred from within the mountain to the surface by the explosive and effusive eruptions during the four years since the beginning of volcanic activity at the summit of Lassen Peak is very small as compared with the results of volcanic eruptions generally, and yet its small size and high point of activity may be important factors in discovering its cause.

In any discussion as to the cause of the recent eruptions a record of the facts as to time and energy is fundamental.

The Forest Service at Red Bluff, W. J. Rushing in charge, furnished most of the important data during the summer when the

rangers were in the field, but at other times Miss Alice Dines, postmaster at Manton, and G. W. Olsen at Chester, both living in sight of the mountain, supplemented the record. The eruptions have been tabulated as to time, intensity, and duration, and the tabulation has

FIG. 7.—Lassen Peak in its twenty-ninth eruption, at 12.30 p. m. August 22, 1914, as seen from Warner Valley near Lees, about 12 miles southeast of the crater. The dust-ladened column of volcanic vapors rises more than 6,000 feet without spreading.

a more or less evident bearing as to the efficiency of certain causes that may affect the eruptions.

The variation as to time of day at which eruptions occur is very irregular and one time of day appears about as favorable as another

FIG. 9.—Eruption of October 6, 1915, seen from Manzanita Lake, at a distance of 5 miles. A column of "smoke," composed of steam, black with volcanic dust, rose from the crater and at a height of about 3,000 feet above the crater spread to the mushroom form shown in figure 9 about 30 minutes after the eruption began. Photo © by C. Mullen, who took three views of the eruption, at 10-minute intervals, to show its progress. The "lid" of new lava, formed about May 22, 1915, fills the old crater at the time this view was taken, but can not be clearly seen on account of new snow and cloud shadows.

for eruption. Of the 220 eruptions up to the end of January, 1916, 143 occurred in the daytime, while 77 occurred at night; that is, between 7 p. m. and 7 a. m. In the daytime 57 eruptions occurred between 7 and 11 a. m., 40 occurred about noon, between 11 a. m. and 3 p. m., while between 3 and 7 p. m. 46 occurred. It has been supposed that a greater supply of surface water might favor eruption. If that is true, we should expect more frequent eruptions in the late afternoon or early evening, when the day's supply of water from melting snow is at its maximum. On the contrary, the mornings have most eruptions, at a time when the daily heat and water supply are near their minimum.

That the volcanic energy is not dependent upon the supply of surface water to form steam is suggested by the fact that summer and autumn, the dry season, with least water, have a greater number (94) of eruptions than (84) the wet season of winter and spring.

In order to determine whether the volcano responds to the tidal wave produced in the crust of the earth by the moon, Mr. Van Orstrand has carefully considered 190 of the best recorded eruptions and concludes that as yet the results are merely suggestive.

If we compare the number of corresponding seasonal eruptions in 1914 and 1915, the result appears significant. In the summer of 1914 there were 38 eruptions, but in 1915 only 17. In the autumn of 1914 there were 56 eruptions, while in 1915 there were only 22. Since the great eruption of May 22, 1915, when the new lava was extruded and the Hat Creek country devastated, the number of eruptions has decreased and the decadence continues, but whether or not the active period of Lassen Peak is approaching its close, although probable, may be more certainly told hereafter.

With its comfortably active volcano, inviting cinder cones and lava fields, vigorously boiling hot springs, mud lakes, and "mush pots" for the volcanologist to study, and the glaciated divides and canyons for the physiographer, in a setting of lovely scenery and attractive camps, for the tourists all easily accessible, the Lassen Peak region affords one of the most alluring and instructive spots for a national park.

J. S. Diller.

U. S. Geological Survey.

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